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THE USE OF ULTRASONIC CUTTING IN THE AUTOMOTIVE INDUSTRY

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1. INTRODUCTION

The ultrasonic process was originally developed to be used in the aerospace industry for cutting pre impregnated carbon, glass or Kevlar fabrics. More recently applications in the automotive industry have been developed where the process is well suited to cut materials such as seat fabrics, leather and some rubbers.

This paper discusses the process of ultrasonic cutting with an emphasis on the attractive environmental properties of the process where energy consumption is low and noise levels comfortable.

2. ULTRASONIC CUTTING

2.1 Fundamentals

The principle of the operation is illustrated in Figure 1. Ultrasonic cutting comprises a blade which is vibrating at an ultrasonic frequency currently 20 Khz, the vibrations being generated using a conventional transducer and specially made horn.

The transducer converts a 20 Khz electrical waveform into small amplitude mechanical vibrations using a crystal. These vibrations are amplified in a combination of booster and horn and the blade moves with an amplitude around 50 microns.

This amplitude is very low when compared with alternative reciprocating blade cutters often used in the automotive industry. The traditional reciprocating knife cutter has a long blade driven by a motor at subsonic frequencies. This process is much noisier than the ultrasonic knife.

To use the ultrasonic blade in an automatic machine for cutting fabrics necessitates a rotary axis motion to ensure that the blade is tangential to the profile being cut.

2.2 Application

2.2.1 XY Cutting

CNC machines have been developed using the ultrasonic principles described above, To date the longest machine has an 'X' axis of 12.5 metres and a 'Y'

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axis of 1.8 metres. This has been complimented with an experimental machine for ultrasonic cutting where the 'X' is 3 metres and the 'Y' is 3 metres. This machine has been used to cut seat pieces from leather and a nest of parts is cut in around 7 minutes. The machine has a maximum axis velocity of 60 metres per minute and an acceleration of 0.5G. Defects are marked on a hide which is subsequently digitised for the outline profile and profiles of the defects. The hide is stored while the nesting takes place interactively. The nest operator determines the location of piece parts on the hide and when he is satisfied with the utilisation the hide is retrieved and transferred to the cutting station.

The main energy requirements on such a machine are drive motors for the gantry and carriage, vacuum pump to hold the work piece on the special pallet and the energy for the ultrasonic head, the generator for which is rated at 450 watts but in reality less than 200 are used for cutting.

2.2.2 Robotic Cutting

Many requirements in the automotive industry call for 3 dimensional cutting and we have successfully incorporated the principles of ultrasonic cutting on conventional robots. We have reduced the size of the ultrasonic head to a 150 watt unit which with its adaptor weighs only 1 kilogramme. Accordingly with this weight and head dimension the accuracy and repeatability claims for the robot are not reduced.

Fixtures have been made from both aluminium and glass fibre, the choice of material depending upon the specific application. It is essential with ultrasonic cutting that the work pieces are supported on a non metallic and non abrasive hard surface in the zone where the material is to be cut.

The fixtures therefore are developed with a groove under the cutter path into which a hard polyurethane strip is fitted to provide the reacting surface for the cutting blade.

The fixtures are drilled in suitable places enabling a component to be held rigid, under vacuum, during the cutting process. In the case of a porous fabric, it is often necessary to cover the fabric with a sheet of polythene to develop the full vacuum to hold the work piece.

3. ENVIRONMENTAL BENEFITS

3.1 Noise

An alternative cutting system that has been considered for trimming fabrics and components is waterjet where water pressures of up to 3000 bar are generated in an intensifier forming a jet up to 0.3 mm in diameter. This process is very noisy with decibel readings in excess of 100 on the A scale. Ear defenders are essential for operators using this type of equipment. The reciprocating knife cutters mentioned earlier do not necessitate ear defenders but do cause a nuisance to some operators. The major environmental hazard with reciprocating knife cutters tends to be vacuum systems where very high to be erected in a special enclosure to reduce flow, low vacuum pumps are used. These often have environmental effects.

With the ultrasonic process the vacuum systems needs less energy and a slow

speed high vacuum pump is used which can be mounted near the machine and causes no complaints. A flow of 400 cu metres per hour is a typical requirement.

3.2 Energy

The maximum power consumed by the cutting head is 450 watts, by a vacuum system is 11 kilowatts. If a waterjet cutter is used then the minimum power requirement exceeds 30 kilowatts which is the smallest built commercially available for high pressure waterjet cutting. The following table provides approximate energy comparisons.

TYPE OF CUTTER	VACUUM SYSTEM POWER KW	CUTTING HEAD POWER KW
RECIPROCATING KNIFE	45	<1
WATERJET	30	Nil
ULTRASONIC	11	<0.5

3.3 Maintenance

Maintenance costs are indirectly an environmental factor. The blades for ultrasonic cutting are made from Tungsten carbide and are designed to be reground and typically have a life of 2-3 weeks between regrinds. In the 6 years since ultrasonic cutting was introduced with over 20 systems installed we have had no cause to replace any transducers or ultrasonic generators. With reciprocating knife cutters, blades are automatically resharpened every few metres and changed every few days. With a waterjet system consumable costs are high in that nozzles, valve stems, valve seats and pump seals need regular attention.

4. CONCLUSION

Advantages of Ultrasonic cutting

The process is quiet, low in energy and low in consumable costs. It is able to cut many fabrics and soft materials that are used in automobiles. In the case of XY cutting a few ply only of fabrics can be cut with the existing geometry of blades. Cutting speeds up to 60 metres per minute are possible.

With the trimming systems high cutting speeds are not so essential but the ability to manipulate the cutter round complex shapes is important. This has been well demonstrated with the compact 150 watt head.

PRINCIPLE OF ULTRASONIC CUTTING

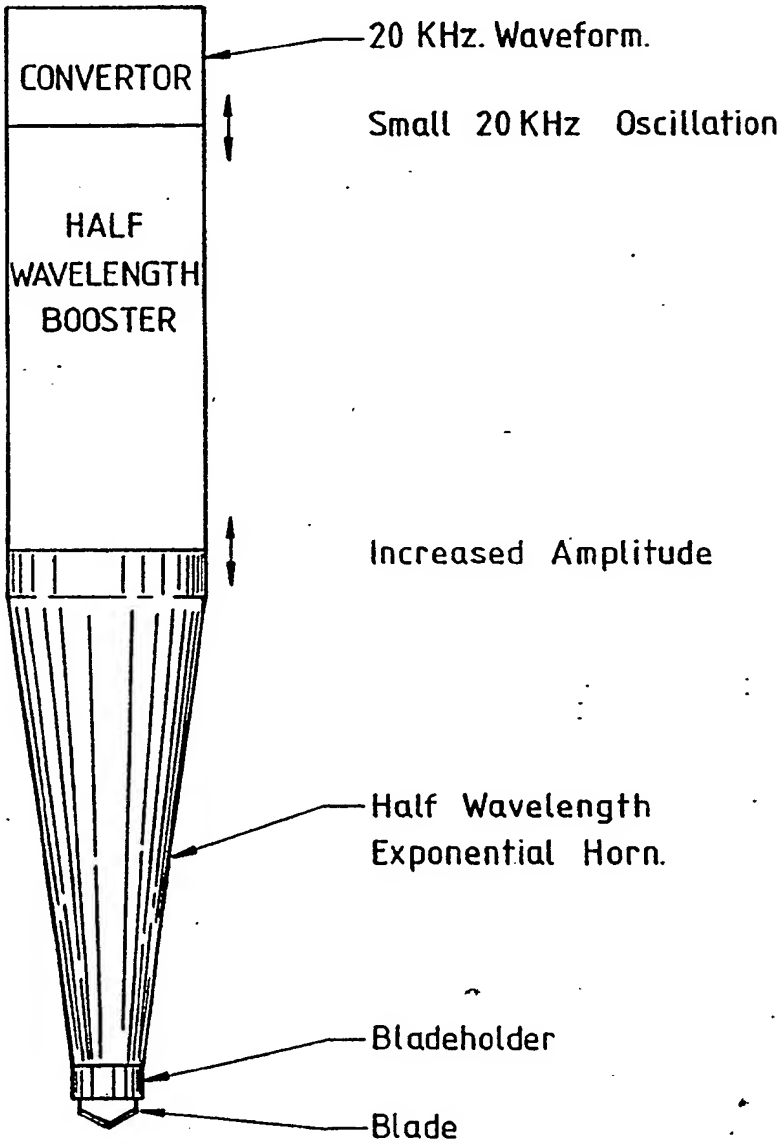

fig 1